

Supplemental Dehumidification in Passive Houses

David Treleven

Agenda

- Advances in Construction
- Latent Loads
- Supplemental Dehumidification & Installations
- Case Study



Advances in Construction - Envelope



Advances in Construction - Mechanicals



Advances = Low-Sensible Load Houses

	Sensible Cooling Load	Latent Cooling Load
Continuous Insulation	↓	▬
Air Tight Construction	↓	↓
Optimized Windows/Shading	↓	▬
Mechanical Ventilation	↓	↑
Ducts in Conditioned Space	↓	▬

Simplified Interior Moisture Balance

$$\begin{array}{ccccccc} \text{Interior} & & \text{Ventilation} & & \text{Exhaust} & & \text{AC} & & \text{Supplementary} \\ \text{Load} & + & \text{Load} & = & \text{Removal} & + & \text{Removal} & + & \text{Dehu Removal} \\ \text{Load} & & & & & & & & \end{array}$$

Latent Load - Internal

Activity	Btuh/person
Light Work	100 Btuh
Medium Work	350 Btuh
Heavy Work	550 Btuh

Family of Four
2000 Btuh



1000 Btuh



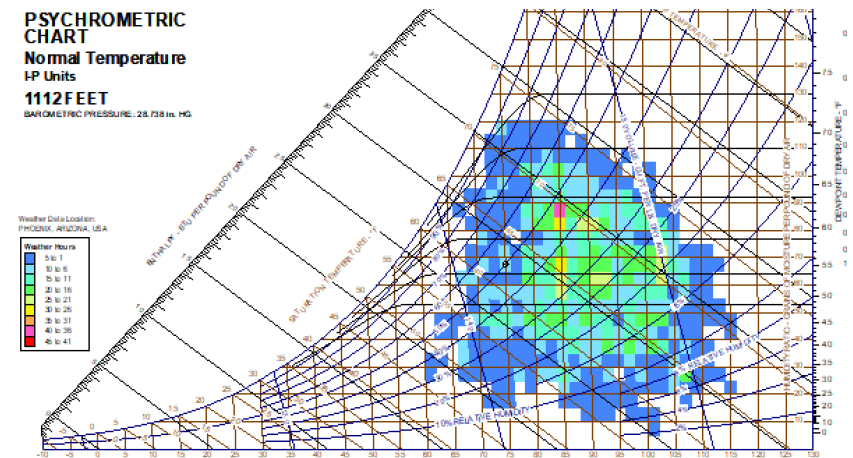
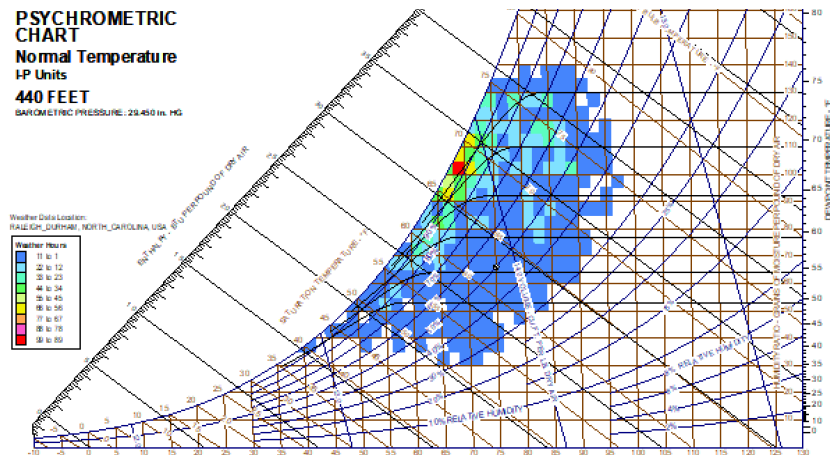
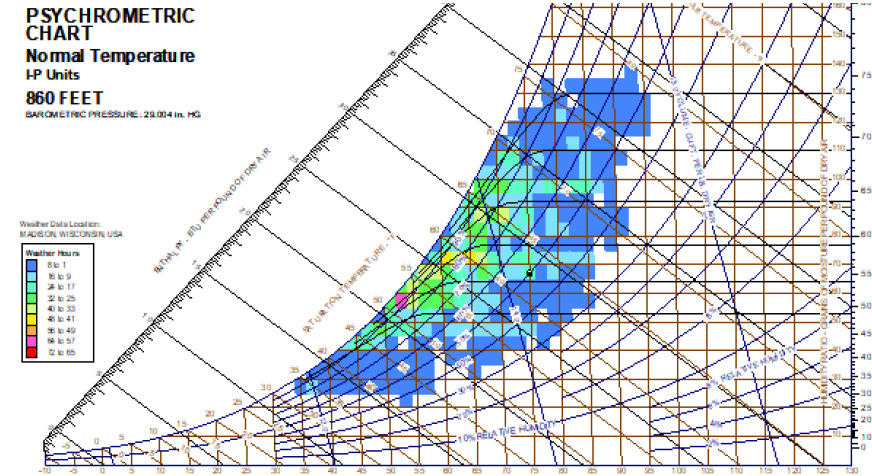
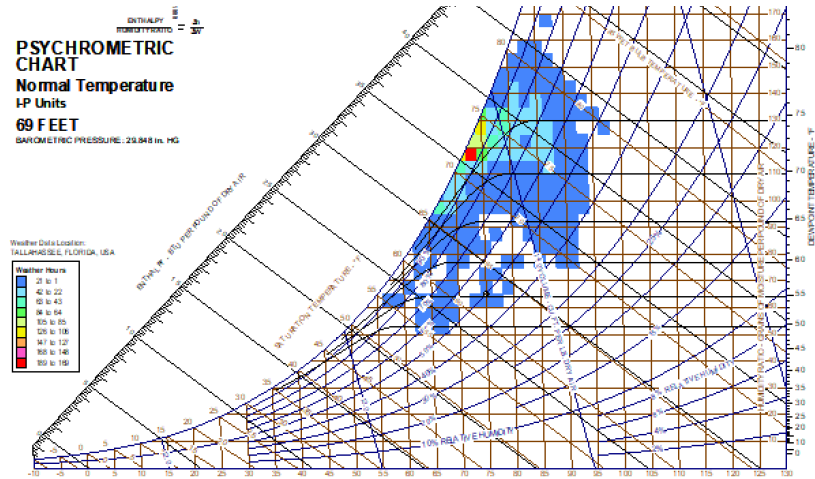
300 Btuh



400 Btuh



Ventilation Load



Ventilation Load

PSYCHROMETRIC CHART

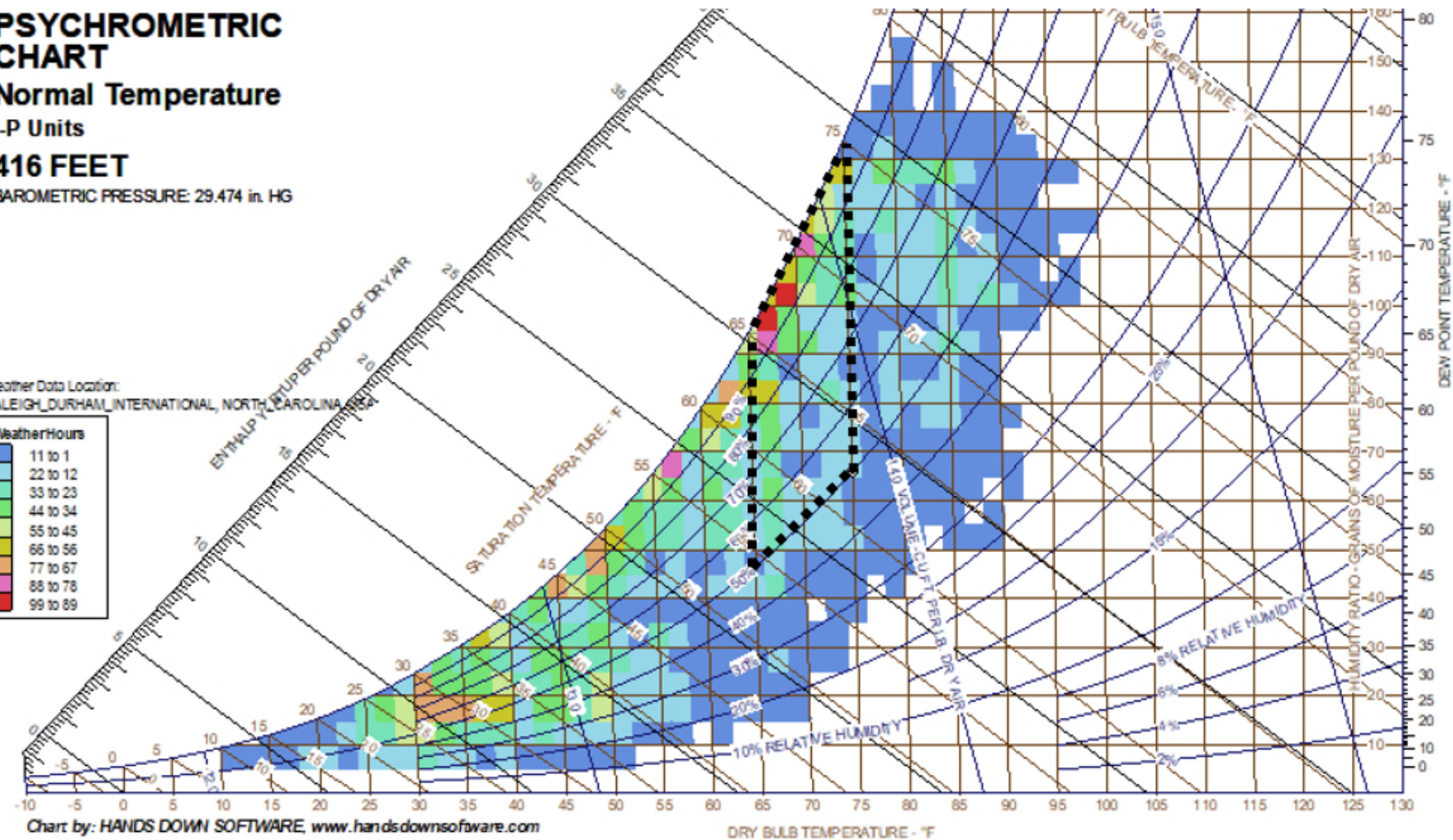
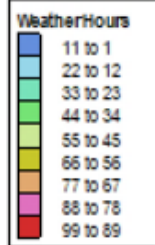
Normal Temperature

I-P Units

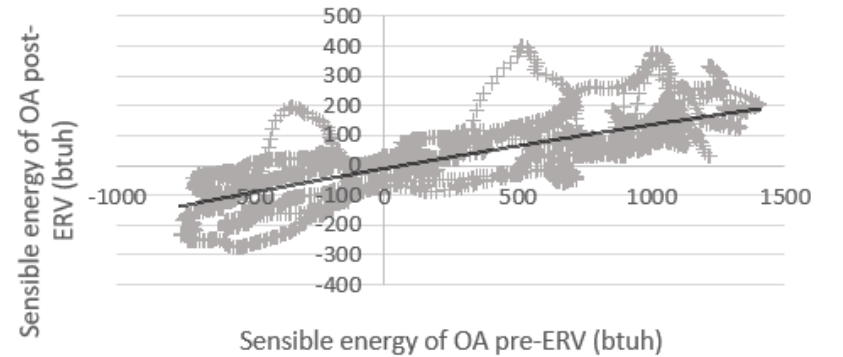
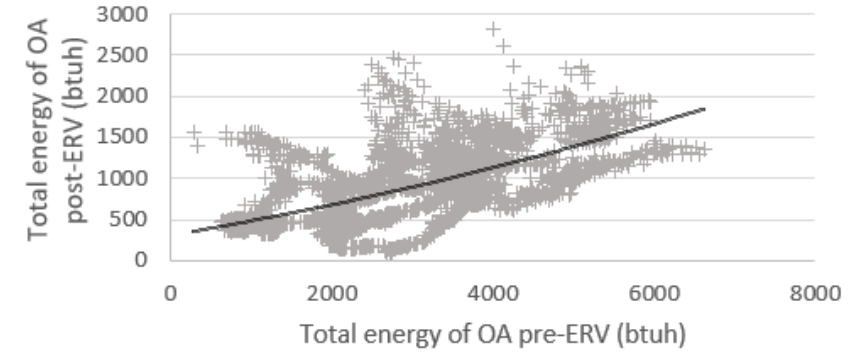
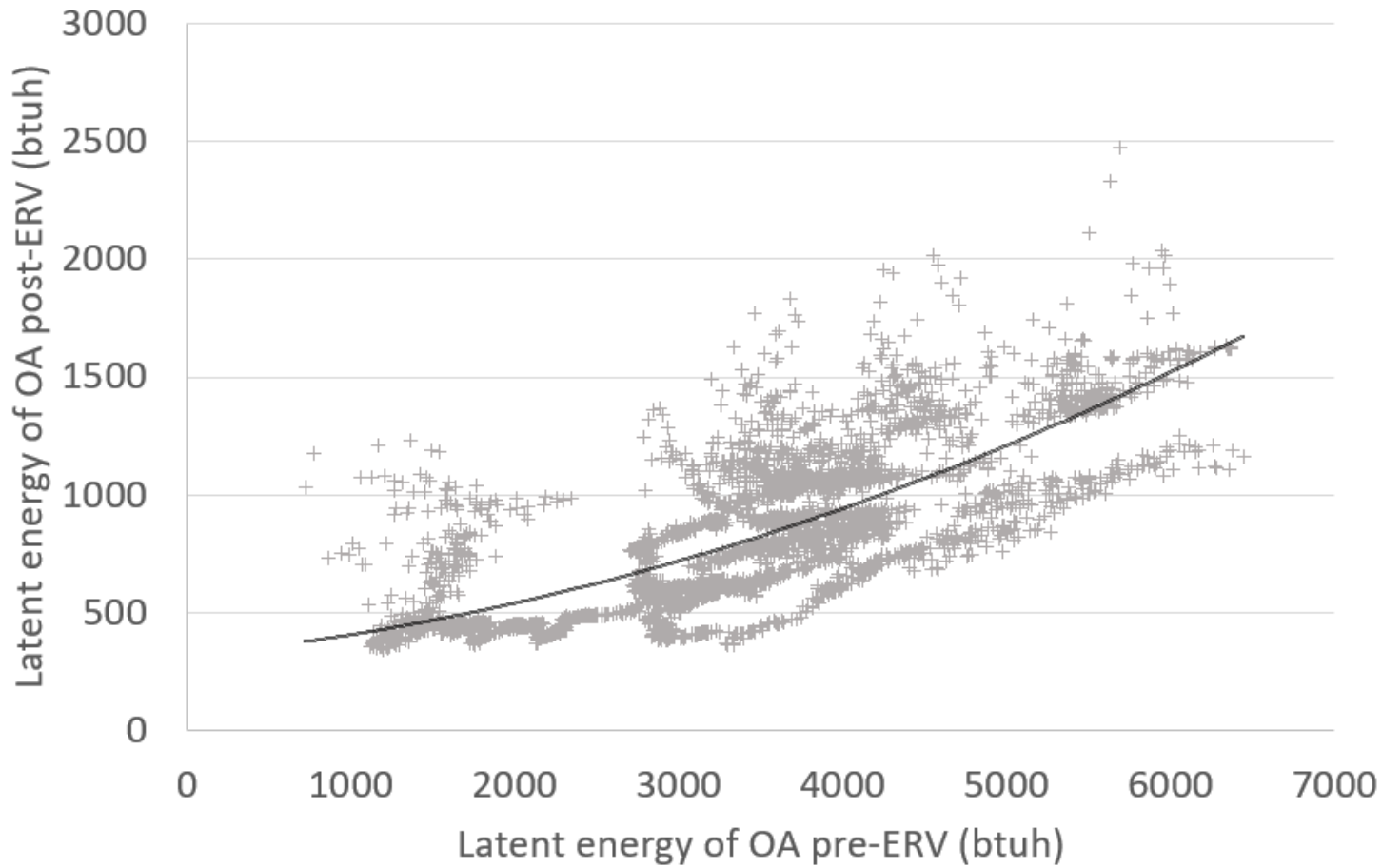
416 FEET

BAROMETRIC PRESSURE: 29.474 in. HG

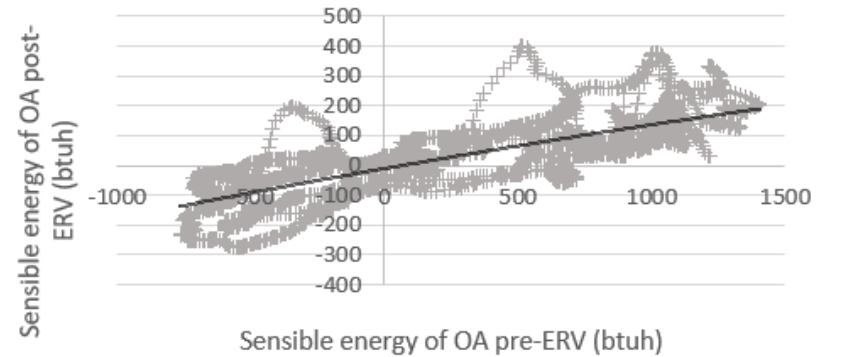
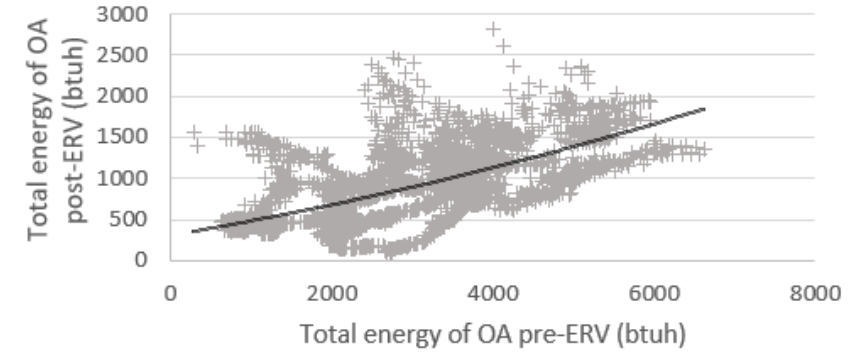
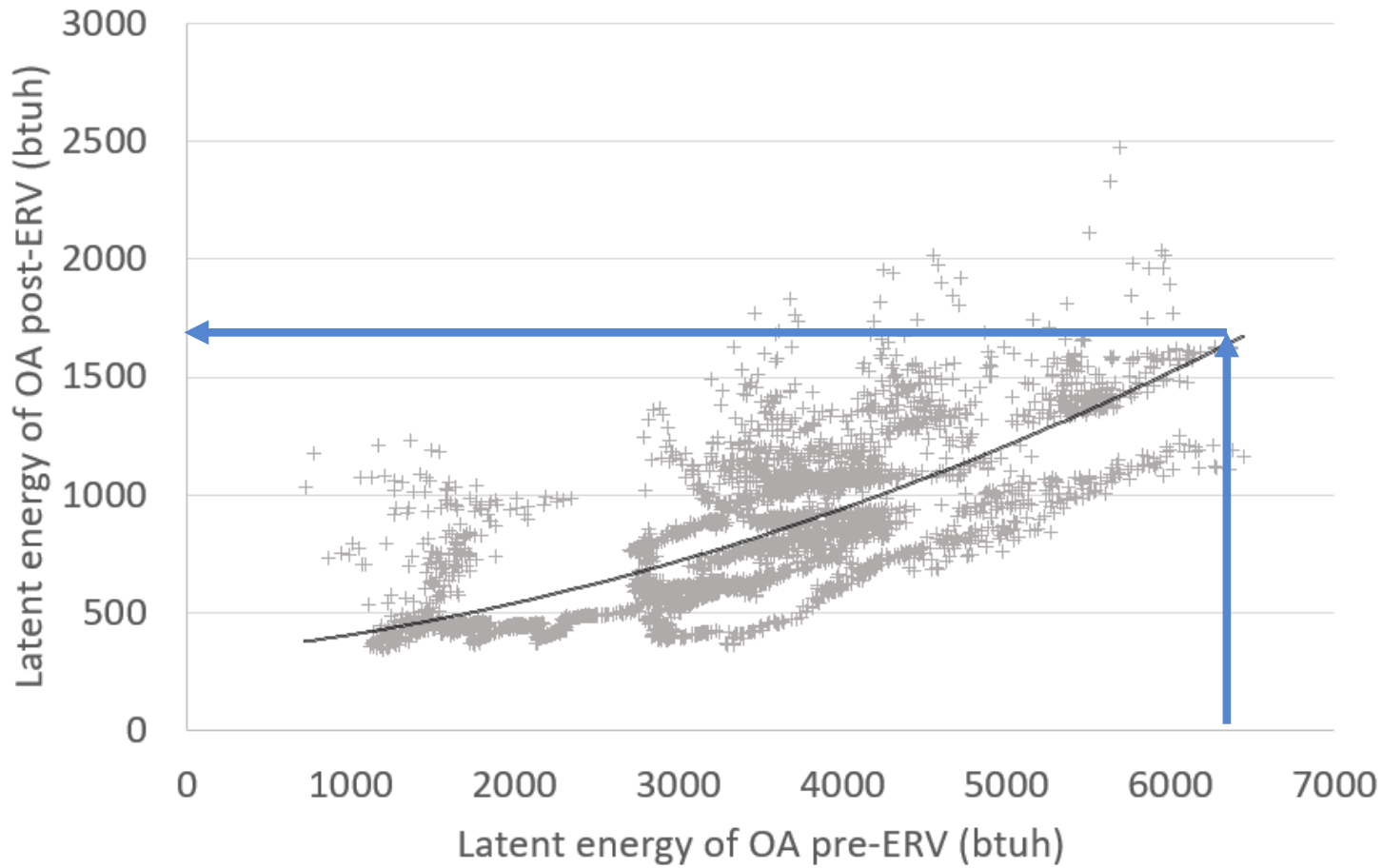
Weather Data Location:
RALEIGH_DURHAM_INTERNATIONAL, NORTH CAROLINA



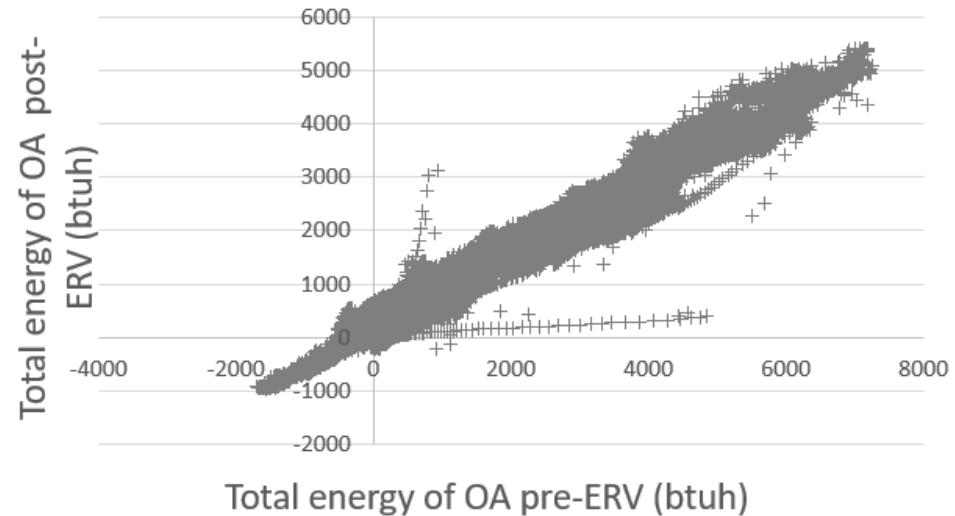
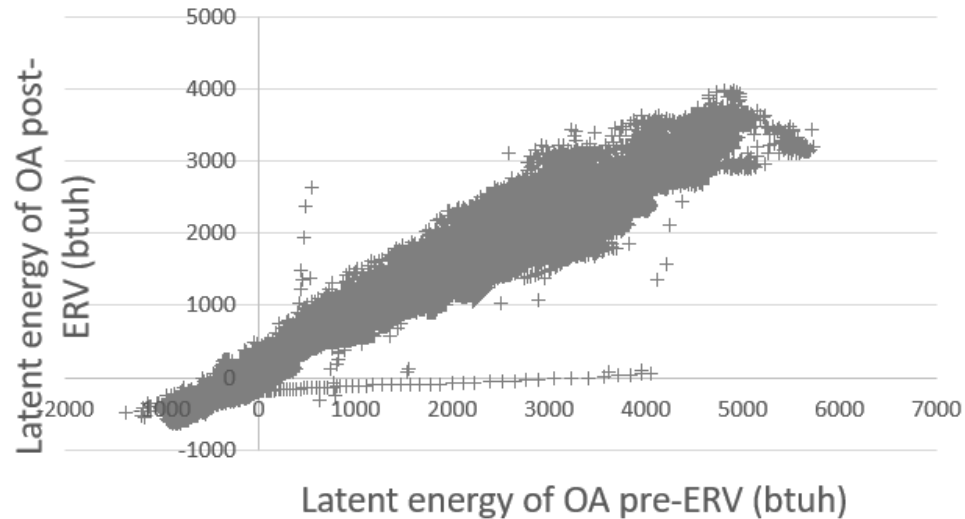
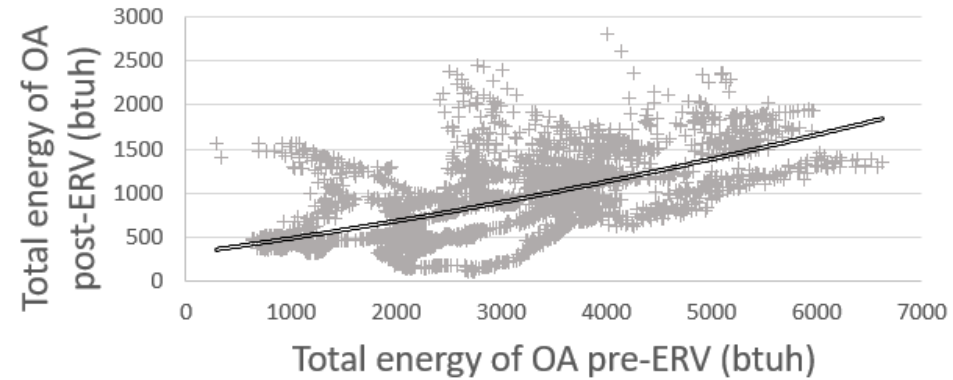
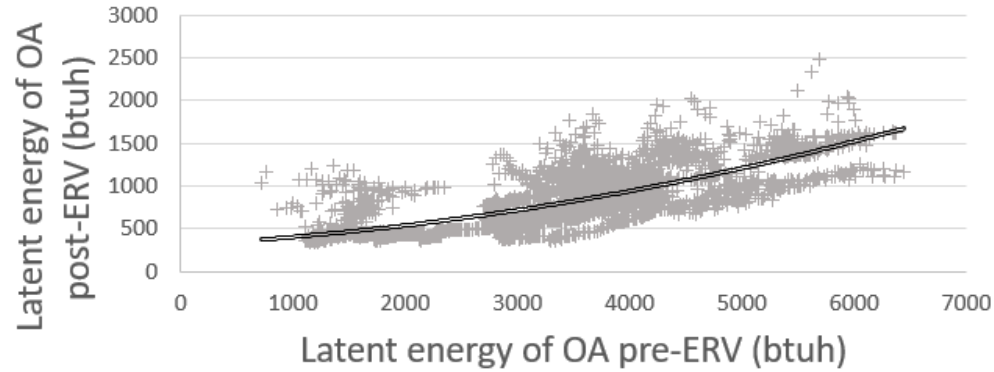
Ventilation Load



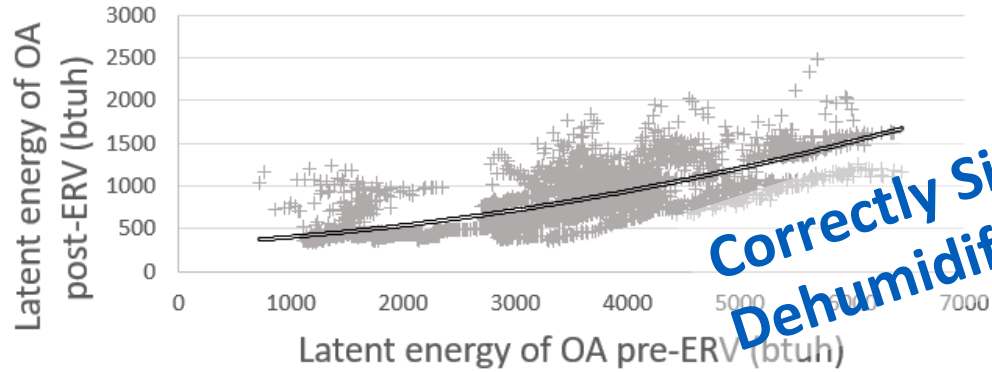
Ventilation Load



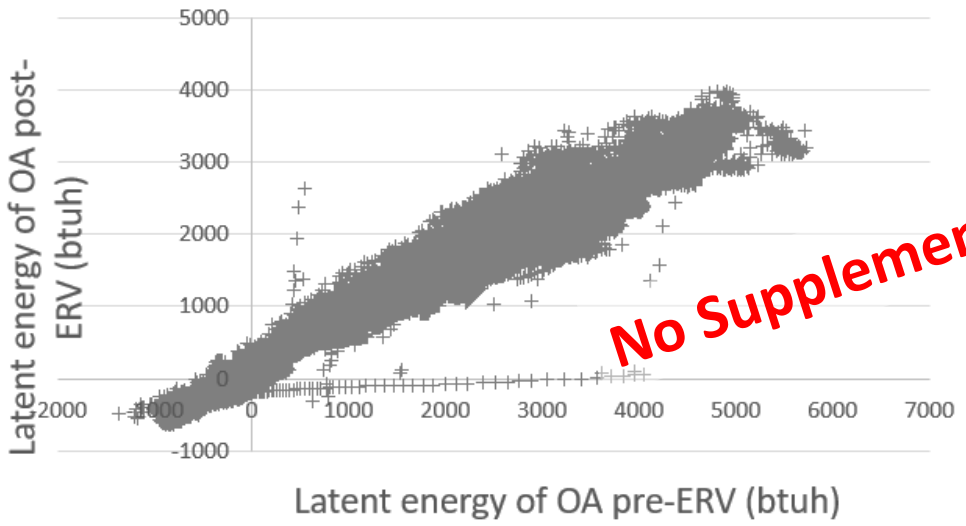
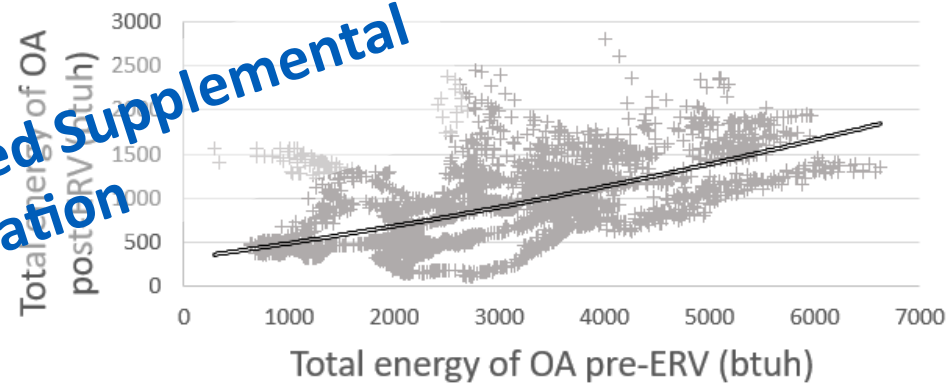
Ventilation Load



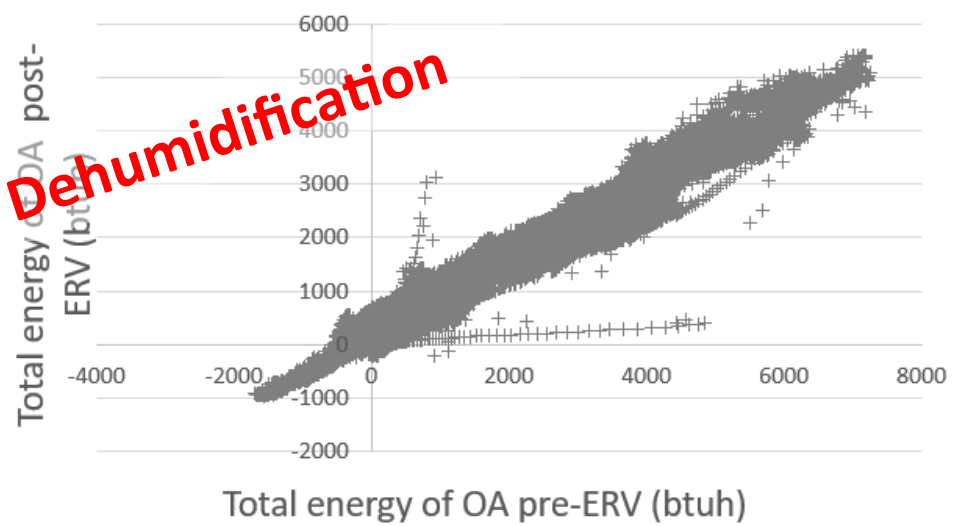
Ventilation Load



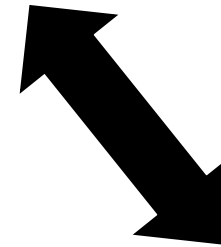
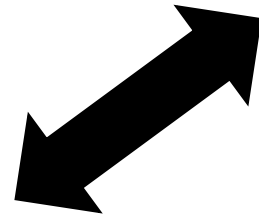
Correctly Sized Supplemental Dehumidification



No Supplemental Dehumidification



Mechanical System



Simplified Interior Moisture Balance

$$\begin{array}{ccccccc} \text{Interior} & & \text{Ventilation} & & \text{Exhaust} & & \text{AC} & & \text{Supplementary} \\ \text{Load} & + & \text{Load} & = & \text{Removal} & + & \text{Removal} & + & \text{Dehu Removal} \\ & & & & & & & & \\ 2000 \text{ Btu/} & & 1600 \text{ Btu/} & & & & & & \\ \text{h} & & \text{h} & & & & & & \end{array}$$

AC Removal



Low-sensible load home – 9kbtu heat pump

Running on high at 0.7 SHR

Total- 9000 Btu/h

Sensible- 6300 Btu/h

Latent- 2700 Btu/h

Running on low at 0.7 SHR (25%)

Total- 2250 Btu/h

Sensible- 1575 Btu/h

Latent- 675 Btu/h

AC Removal – Dependent on Temperature

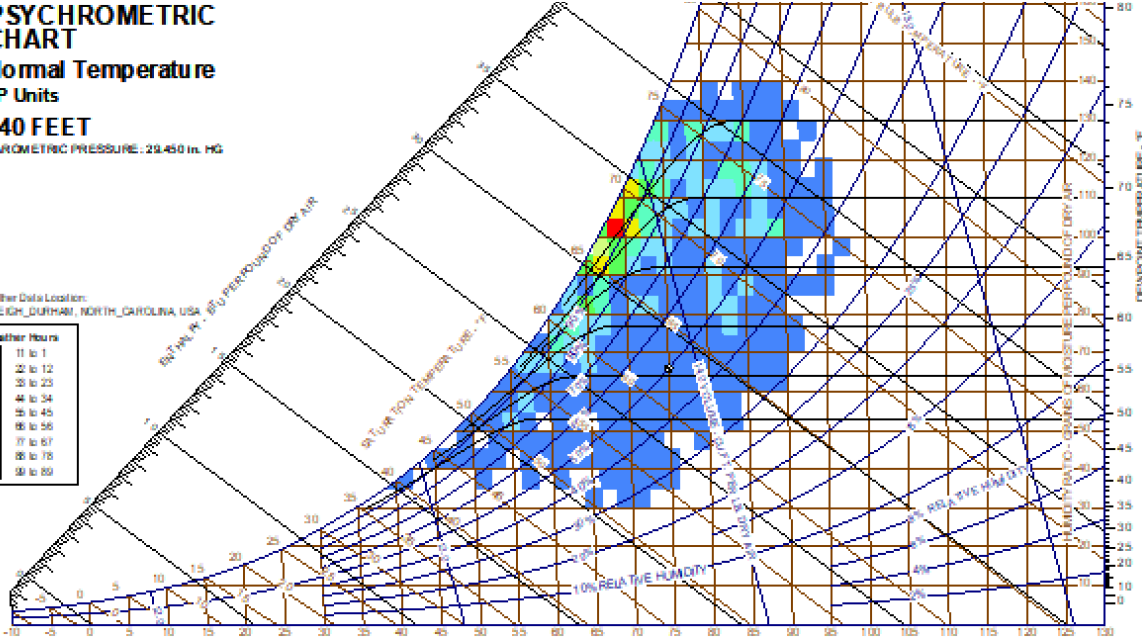
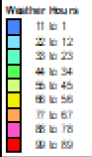
PSYCHROMETRIC CHART

Normal Temperature
IP Units

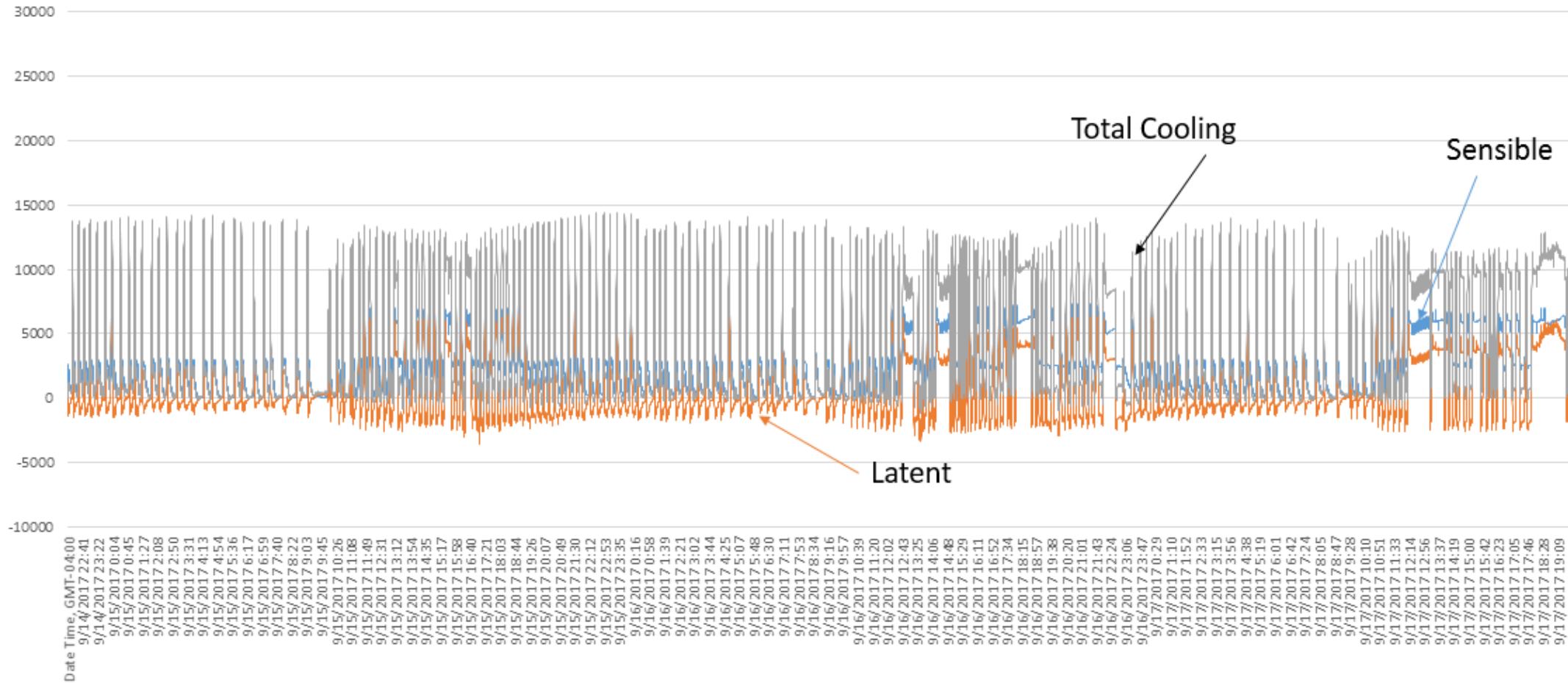
440 FEET

BAROMETRIC PRESSURE: 29.450 in. HG

Weather Data Location:
RALEIGH, DURHAM, NORTH CAROLINA, USA



AC Removal - Result



AC Removal



Low-sensible load home – 9kbtu heat pump

Running on high at 0.7 SHR

Total- 9000 Btu/h

Sensible- 6300 Btu/h

Latent- 2700 Btu/h

Running on low at 0.7 SHR (25%)

Total- 2250 Btu/h

Sensible- 1575 Btu/h

Latent- 675 Btu/h

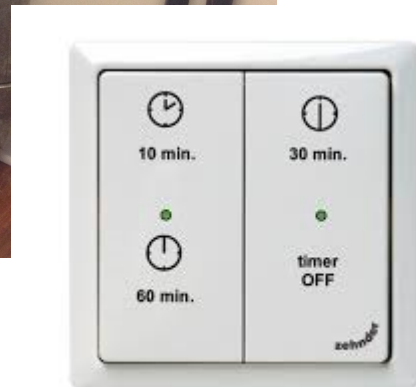
Simplified Interior Moisture Balance

$$\begin{array}{ccccccc} \text{Interior} & & \text{Ventilation} & & \text{Exhaust} & & \text{AC} & & \text{Supplementary} \\ \text{Load} & + & \text{Load} & = & \text{Removal} & + & \text{Removal} & + & \text{Dehu Removal} \\ & & & & & & & & \\ 2000 \text{ Btu/} & & 1600 \text{ Btu/} & & & & 700 & & \\ \text{h} & & \text{h} & & & & \text{Btu/h} & & \end{array}$$

Exhaust Removal



~ 500 Btu/h
Highly Variable



Simplified Interior Moisture Balance

$$\begin{array}{ccccccc} \text{Interior} & & \text{Ventilation} & & \text{Exhaust} & & \text{AC} & & \text{Supplementary} \\ \text{Load} & + & \text{Load} & = & \text{Removal} & + & \text{Removal} & + & \text{Dehu Removal} \\ & & & & & & & & \\ 2000 \text{ Btu/} & & 1600 \text{ Btu/} & & 500 & & 700 & & \\ \text{h} & & \text{h} & & \text{Btu/h} & & \text{Btu/h} & & \end{array}$$

Simplified Interior Moisture Balance

$$\begin{array}{ccccccccc} \text{Interior} & & \text{Ventilation} & & \text{Exhaust} & & \text{AC} & & \text{Supplementary} \\ \text{Load} & + & \text{Load} & = & \text{Removal} & + & \text{Removal} & + & \text{Dehu Removal} \\ & & & & & & & & \\ 2000 \text{ Btu/} & & 1600 \text{ Btu/} & & 500 & & 700 & & 2400 \\ \text{h} & & \text{h} & & \text{Btu/h} & & \text{Btu/h} & & \text{Btu/h} \end{array}$$

Simplified Interior Moisture Balance

$$\begin{array}{ccccccccc} \text{Interior} & & \text{Ventilation} & & \text{Exhaust} & & \text{AC} & & \text{Supplementary} \\ \text{Load} & + & \text{Load} & = & \text{Removal} & + & \text{Removal} & + & \text{Dehu Removal} \\ & & & & & & & & \\ 1200 \text{ Btu/} & & 1400 \text{ Btu/} & & 0 & & 1000 & & 1600 \\ \text{h} & & \text{h} & & \text{Btu/h} & & \text{Btu/h} & & \text{Btu/h} \end{array}$$

Simplified Interior Moisture Balance

$$\begin{array}{rclcl} \text{Interior} & & \text{Ventilation} & & \\ \text{Load} & + & \text{Load} & = & \text{Exhaust} & + & \text{AC} \\ & & & & \text{Removal} & & \text{Removal} \\ \\ 1200 \text{ Btu/} & & 1400 \text{ Btu/} & & 0 & & 1000 \\ \text{h} & & \text{h} & & \text{Btu/h} & & \text{Btu/h} \end{array}$$

Supplementary
Dehu Removal

1600
Btu/h

Supplemental Dehumidification

Important Dehumidifier Information:

- Dehumidifiers are rated @ 80F/60%RH – 0.0 IWG (AHAM)
- Pint ~ 1000 Btu/h
- Heat generated – 3.46 Btu/h per Watt & 1000 Btu/h per pint of water removed



@ 75F/50%RH – 0.2 IWG
Latent – 1700 Btu/h
Sensible added - 3500 Btu/h

Supplemental Dehumidification

**Performance
Summary:**

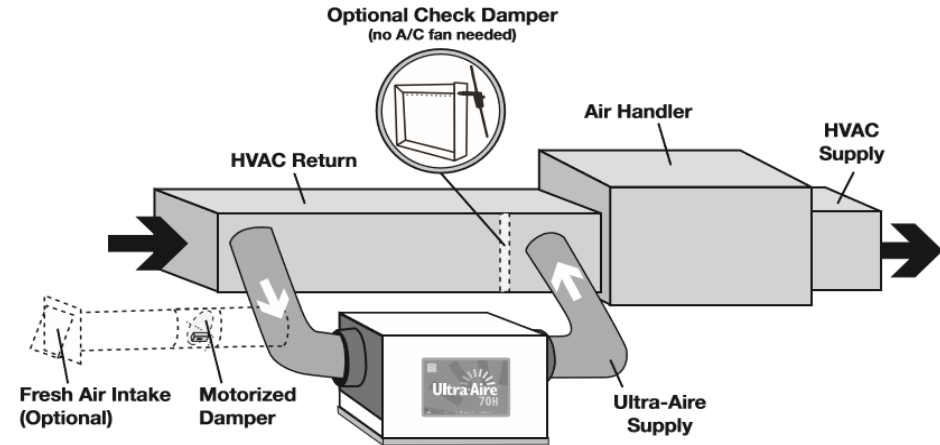
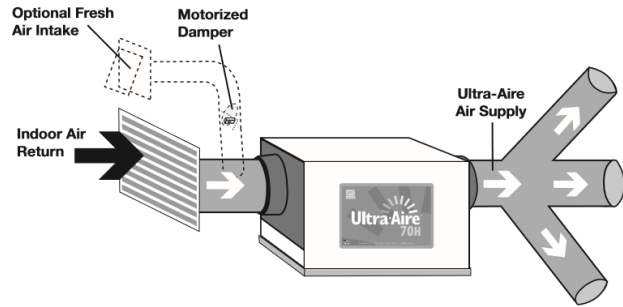
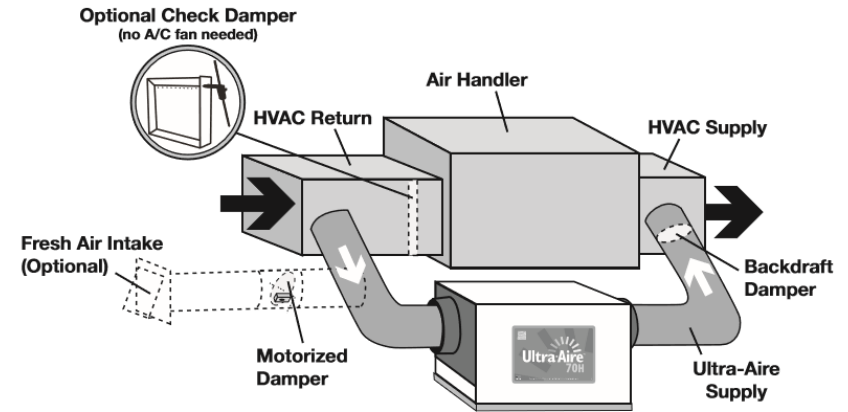
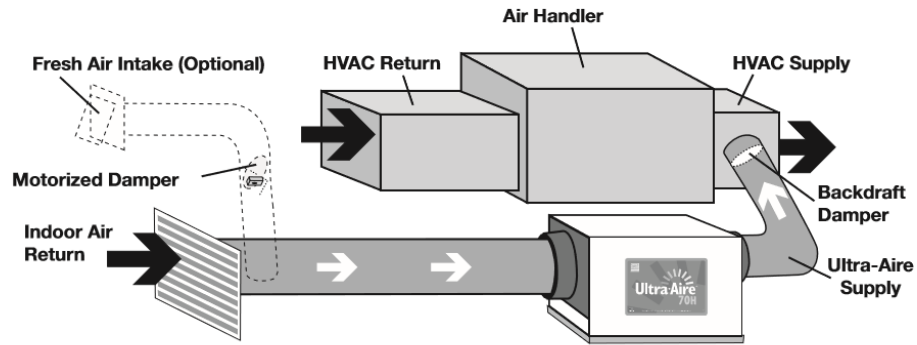
		Static Pressure									
		0"		0.2"		0.4"		0.6"		0.8"	
TEMP	RH	PPD		PPD		PPD		PPD		PPD	
60	40%	13.8		5.2		4.4		3		0	
60	50%	38.5		33.8		26.3		19.8		-4.4	
60	60%	64.2		62		54		57.4		49.8	
65	40%	43.3		36.5		33.1		32		19.1	
65	50%	64.3		64.2		62.6		52		48.5	
65	60%	86.6		85.1		81.5		80.2		68.2	
70	40%	52.2		52.2		52.3		42.7		43.6	
70	50%	76.2		73.7		71.1		69.5		67.3	
70	60%	96.2		96.2		91.1		91.3		82.8	
80	40%	69.8		70		68.5		67.6		67	
80	50%	98.9		100.5		94.7		94		87.7	
80	60%	125.2		126		121		118		109.4	

Supplemental Dehumidification

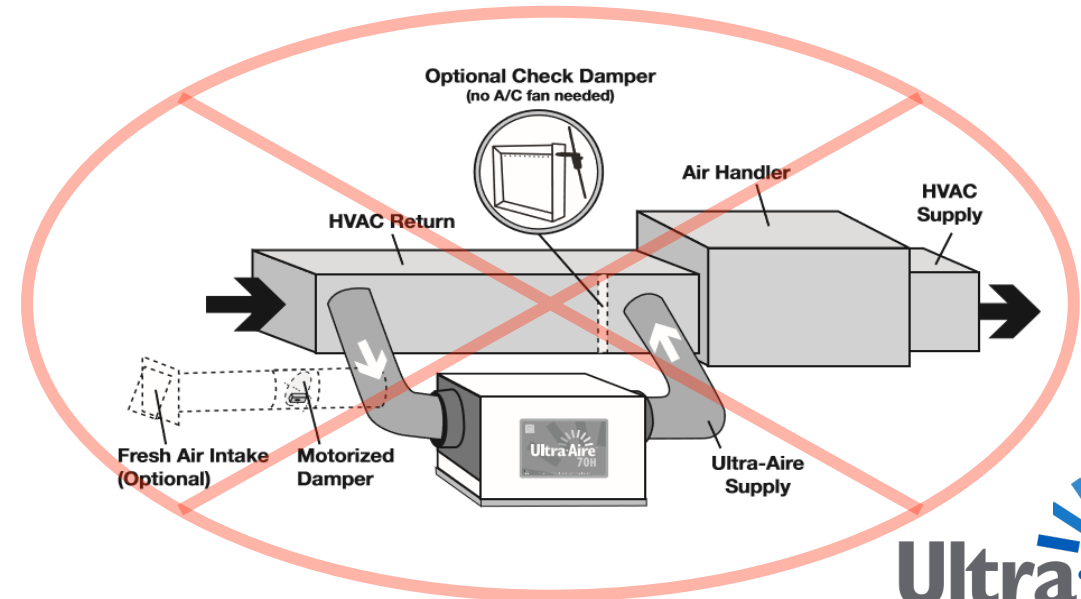
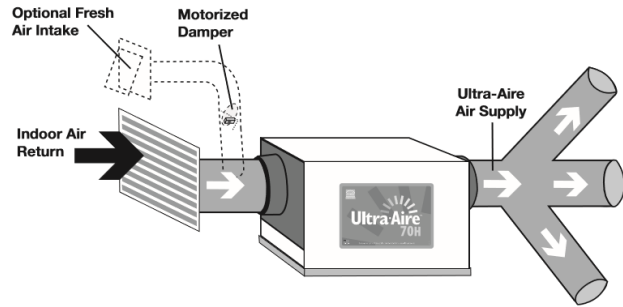
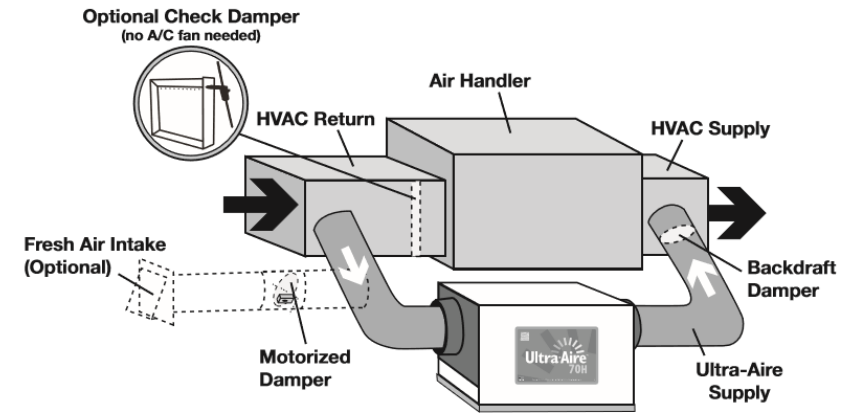
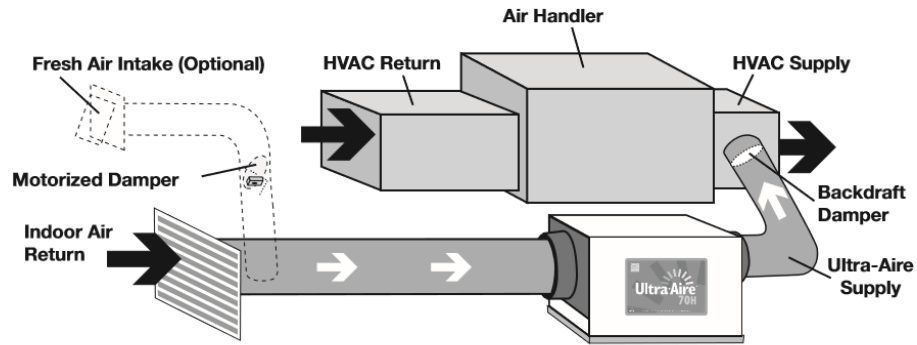
Performance Summary:

		Static Pressure									
		0"		0.2"		0.4"		0.6"		0.8"	
TEMP	RH	PPD		PPD		PPD		PPD		PPD	
60	40%	13.8		5.2		4.4		3		0	
60	50%	38.5		33.8		26.3		19.8		-4.4	
60	60%	64.2		62		54		57.4		49.8	
65	40%	43.3		36.5		33.1		32		19.1	
65	50%	64.3		64.2		62.6		52		48.5	
65	60%	86.6		85.1		81.5		80.2		68.2	
70	40%	52.2		52.2		52.3		42.7		43.6	
70	50%	76.2	→	73.7		71.1		69.5		67.3	
70	60%	96.2		96.2		91.1		91.3		82.8	
80	40%	69.8		70		68.5		67.6		67	
80	50%	98.9		100.5		94.7		94		87.7	
80	60%	125.2		126		121		118		109.4	

Whole Home Dehumidifier Installation



Whole Home Dehumidifier Installation

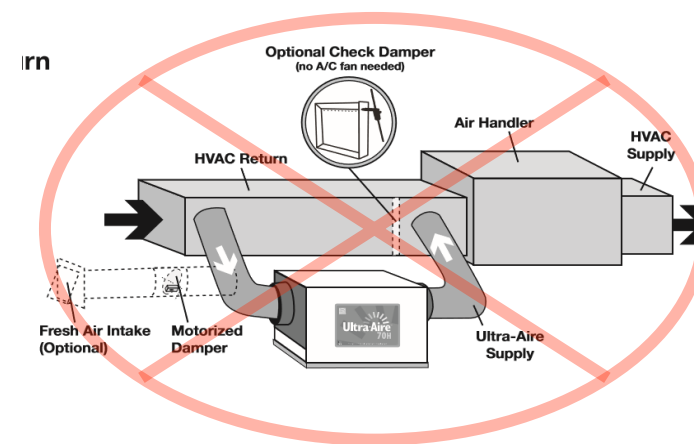


Whole Home Dehumidifier Installation

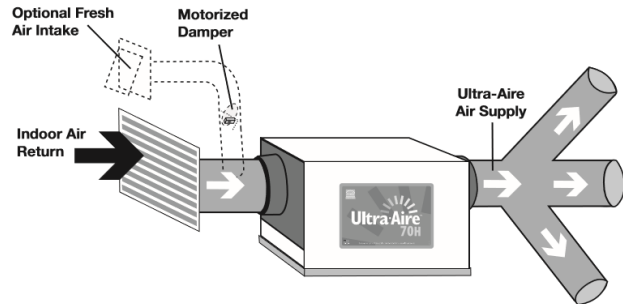
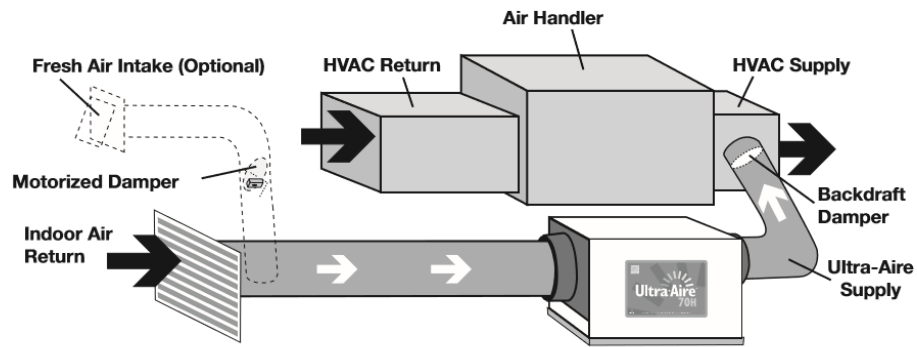
FSEC – June 2018 – FSEC-CR-2028-18

DHU ducted from/to central return had the highest daily energy use and resulted in two primary causes of latent performance degradation.

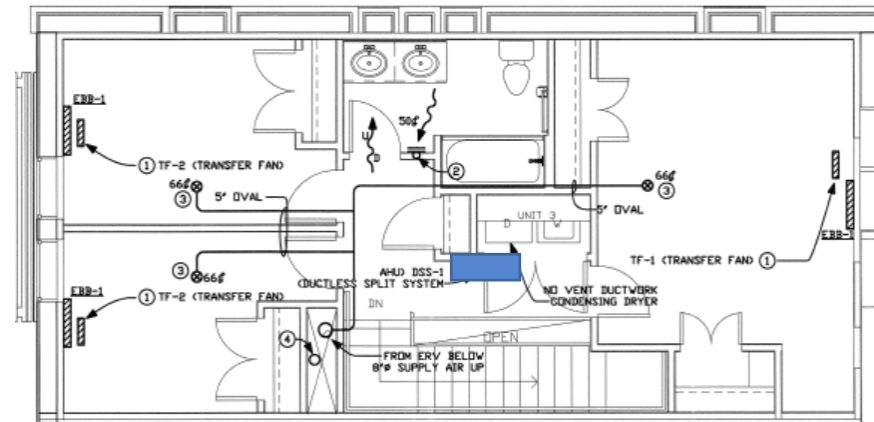
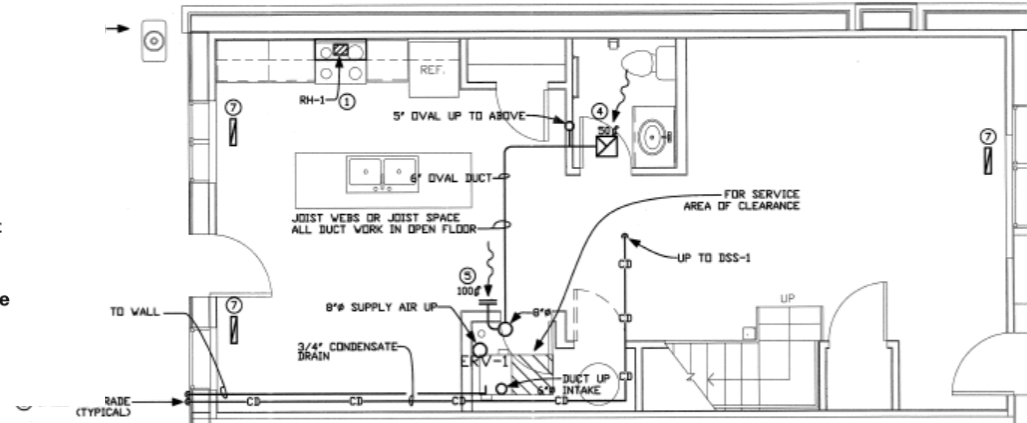
- DHU air degraded central latent cooling performance during simultaneous operations of both AC and DHU appliances. Temporary steady-state testing, with both the central cooling system and DHU operating at the same time, found that the central cooling latent performance was decreased by 28% compared to when no DH was operating at the same time.
- DHU air re-evaporated water off of warm central coil when AC was cycled off. Temporary steady-state testing just after the central system cycled off, with the DHU operating 28 continuous minutes after, measured a total 1.5 lbs of water re-evaporated off of the central cooling coil (rate of 3.2 lb/h back into condition space).
- During one 15 minute period observation of uninterrupted monitoring, the moisture pulled out of the room air by the DHU was at about the same rate that was being re-evaporated off of the central cooling coil while the AC was cycled off. In this instance the DHU coil rate of latent removal was -1.8 lb/h and the latent heat due to evaporation from the central cooling coil was +1.9 lb/h into the space while the DH was operating steady and the central cooling system had remained naturally cycled off 1.25 hours prior during very low cooling load period in the early morning.



Whole Home Dehumidifier Installation



@ 75F/50%RH – 0.2 IWG
 Latent – 1700 Btu/h
 Sensible added - 3500 Btu/h



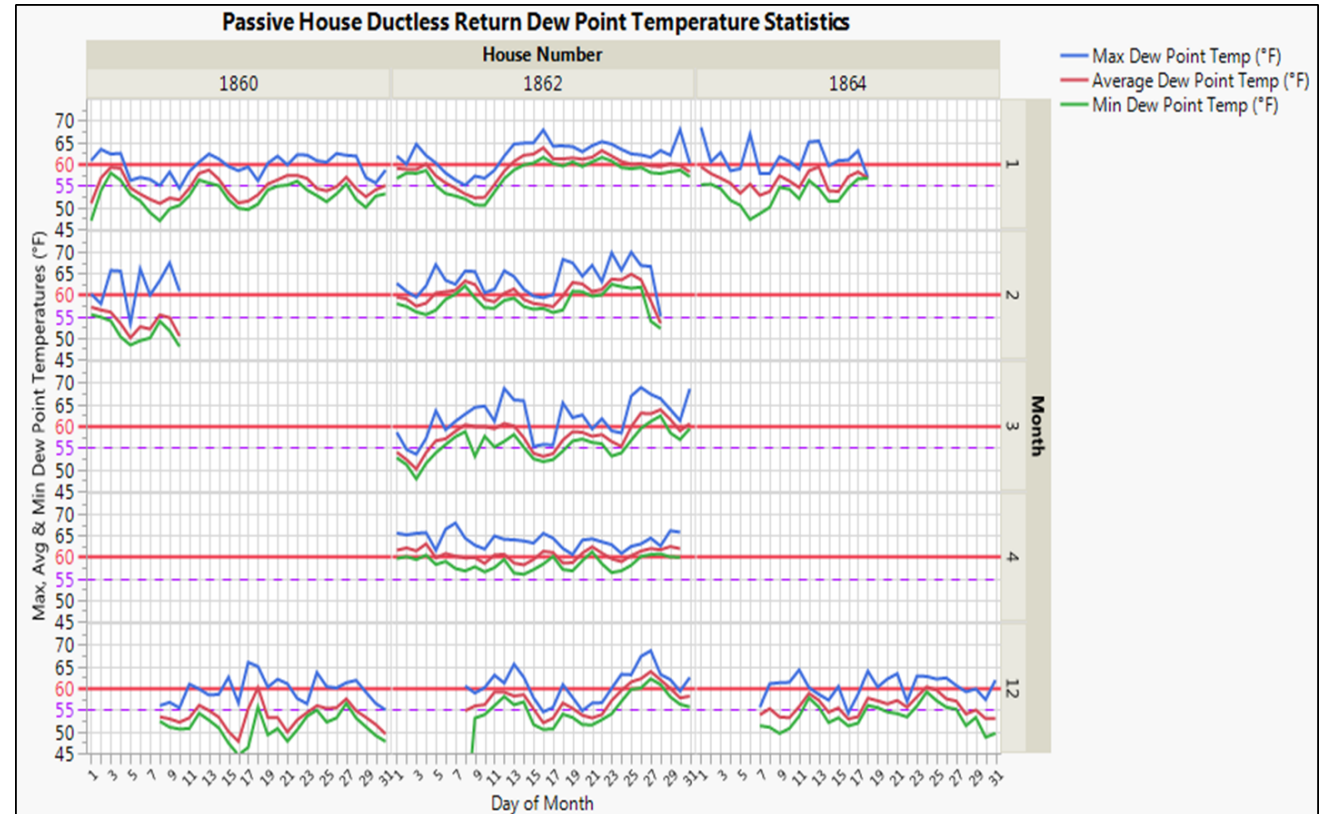
Case Study

DC HFH – Passive Townhomes



Previous Work

- Low-load homes in mixed-humid climates
- Mini-splits
 - Ductless
 - Ducted mini-splits
 - Combo
- Higher interior dew points than expected



Treleven, David. "Performance Monitoring of Mini-Splits in Mixed-Humid Low-Load Homes." 12th Annual North American Passive House Conference

Dehumidifier Selection



Retrofit Application – Ductless Mini-Split/No Space for Integration with ERV

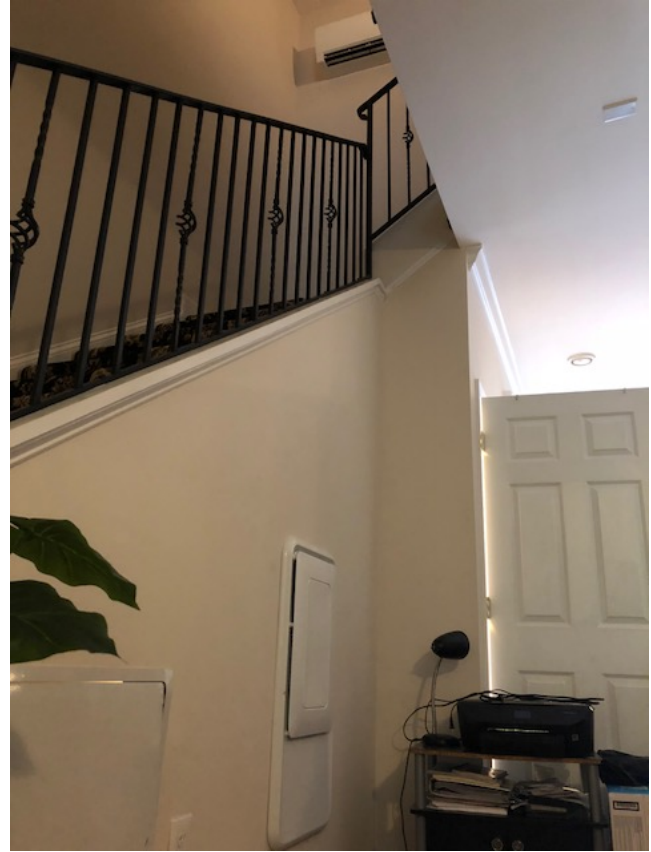
In-Wall Dehumidifier

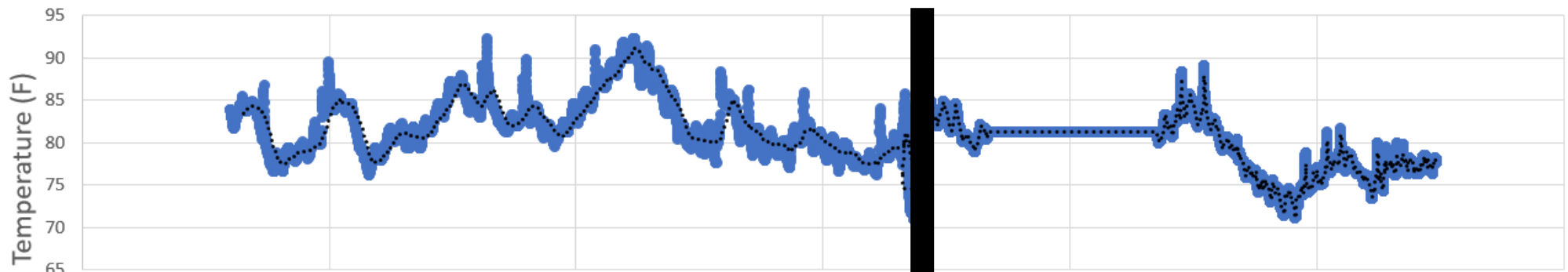
@75F/50F

Latent- 800 Btu/h

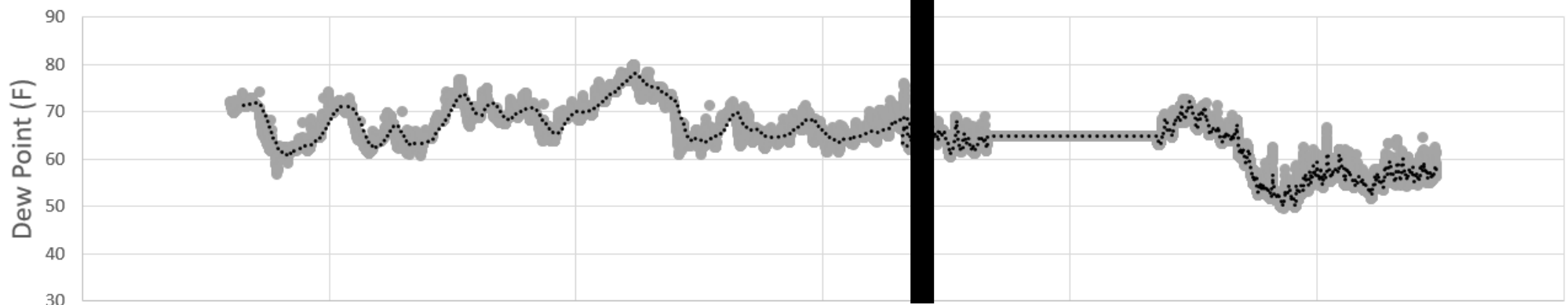
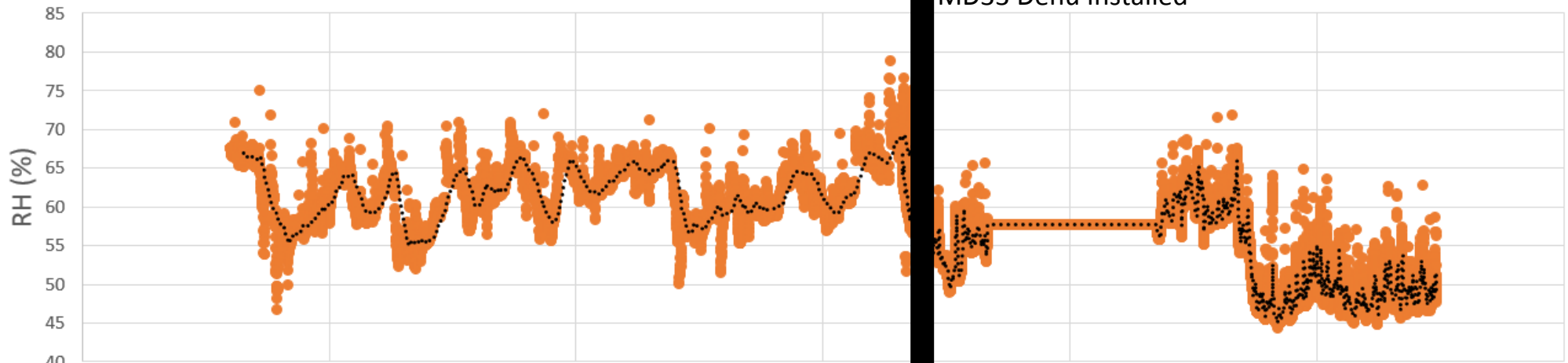
Sensible added - 1500 Btu/h

Dehumidifier Installation

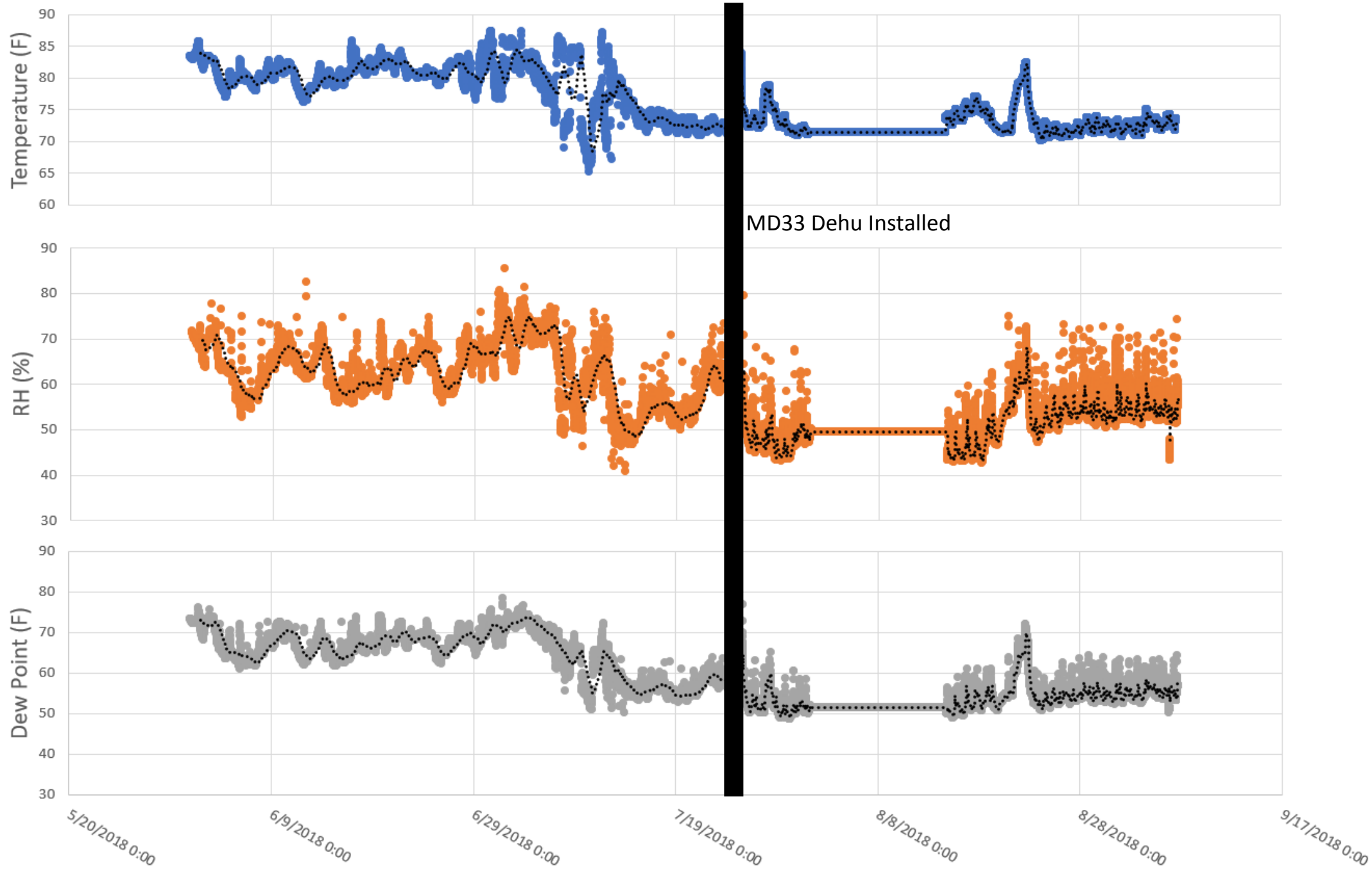


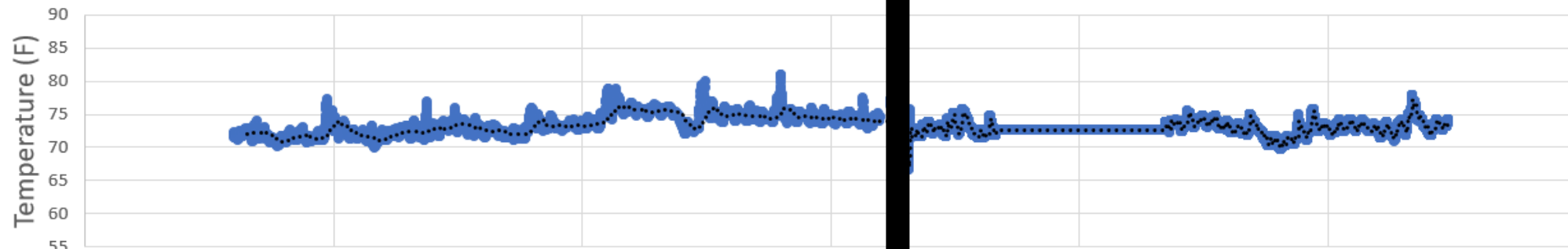


MD33 Dehu Installed

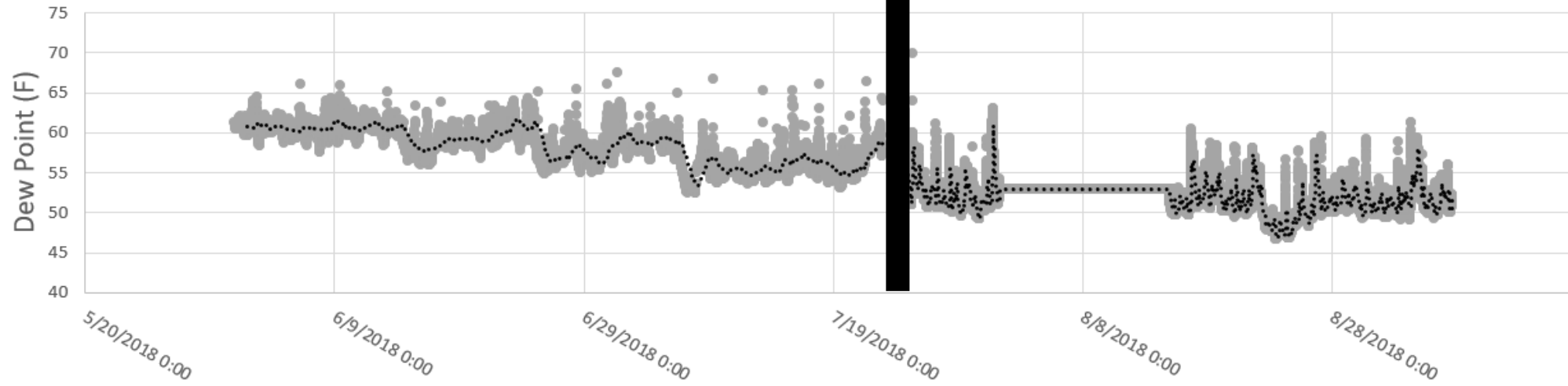
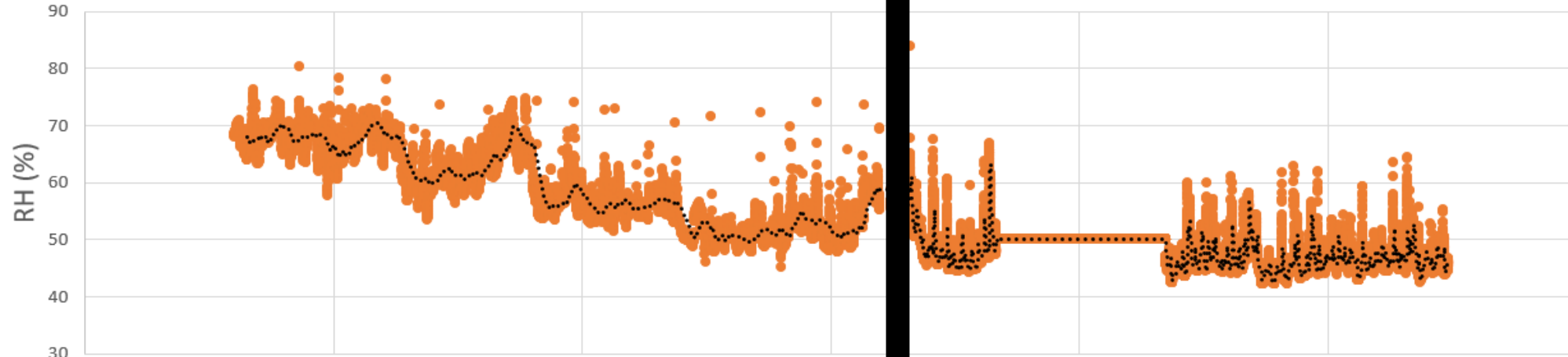


5/20/2018 0:00 6/9/2018 0:00 6/29/2018 0:00 7/19/2018 0:00 8/8/2018 0:00 8/28/2018 0:00 9/17/2018 0:00

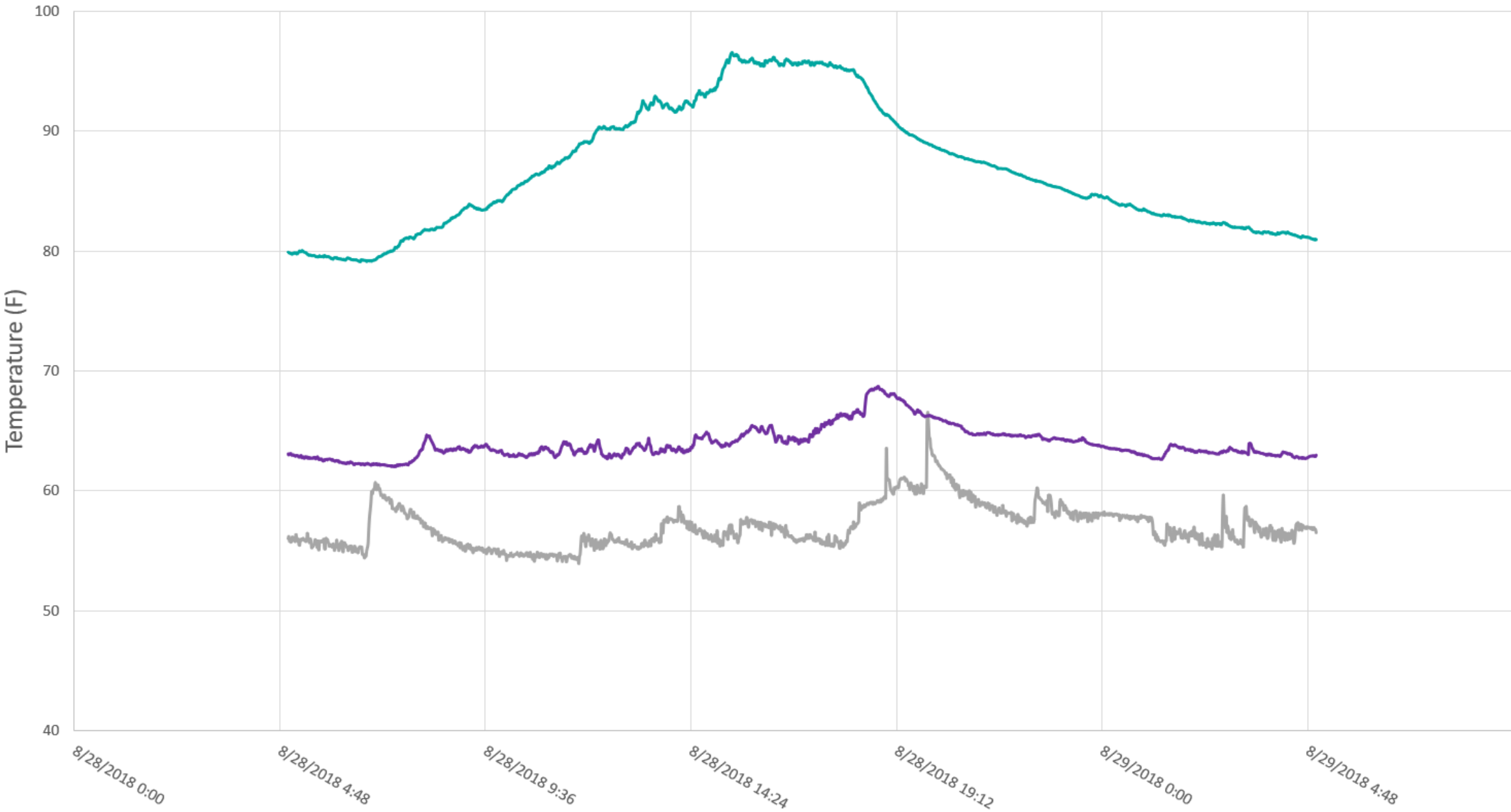




MD33 Dehu Installed

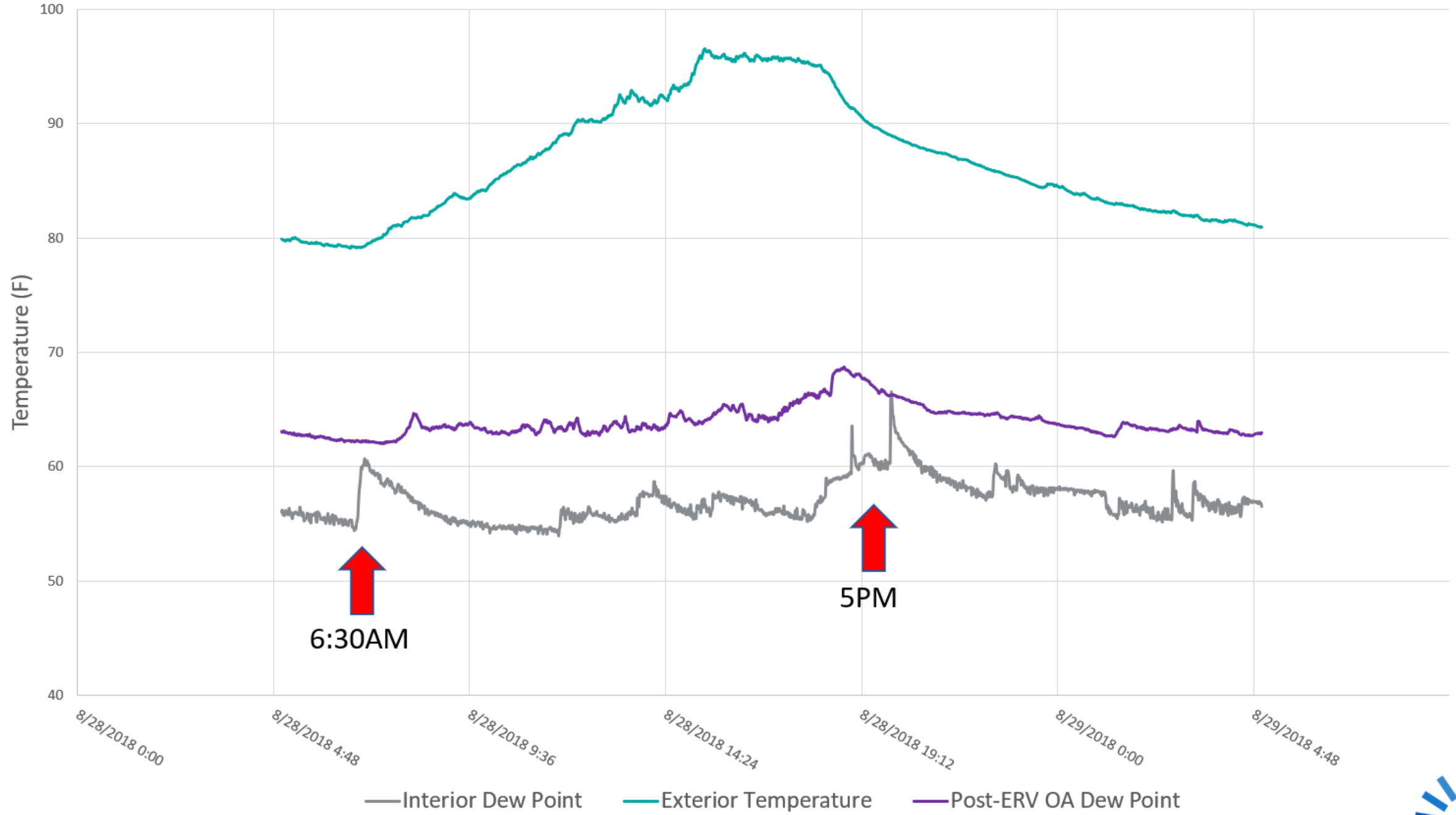


5/20/2018 0:00 6/9/2018 0:00 6/29/2018 0:00 7/19/2018 0:00 8/8/2018 0:00 8/28/2018 0:00 9/17/2018 0:00



— Interior Dew Point — Exterior Temperature — Post-ERV OA Dew Point





— Interior Dew Point — Exterior Temperature — Post-ERV OA Dew Point



Cost to Operate

33 Pint- Dehumidifier

% Runtime	25	50	75	100
Hours per day	6	12	18	24
kWh/day	1.722	3.444	5.166	6.888
\$/day	0.17	0.34	0.51	0.68
kWh/month	51.66	103.32	154.98	206.64
\$/month	5.16	10.33	15.49	20.66

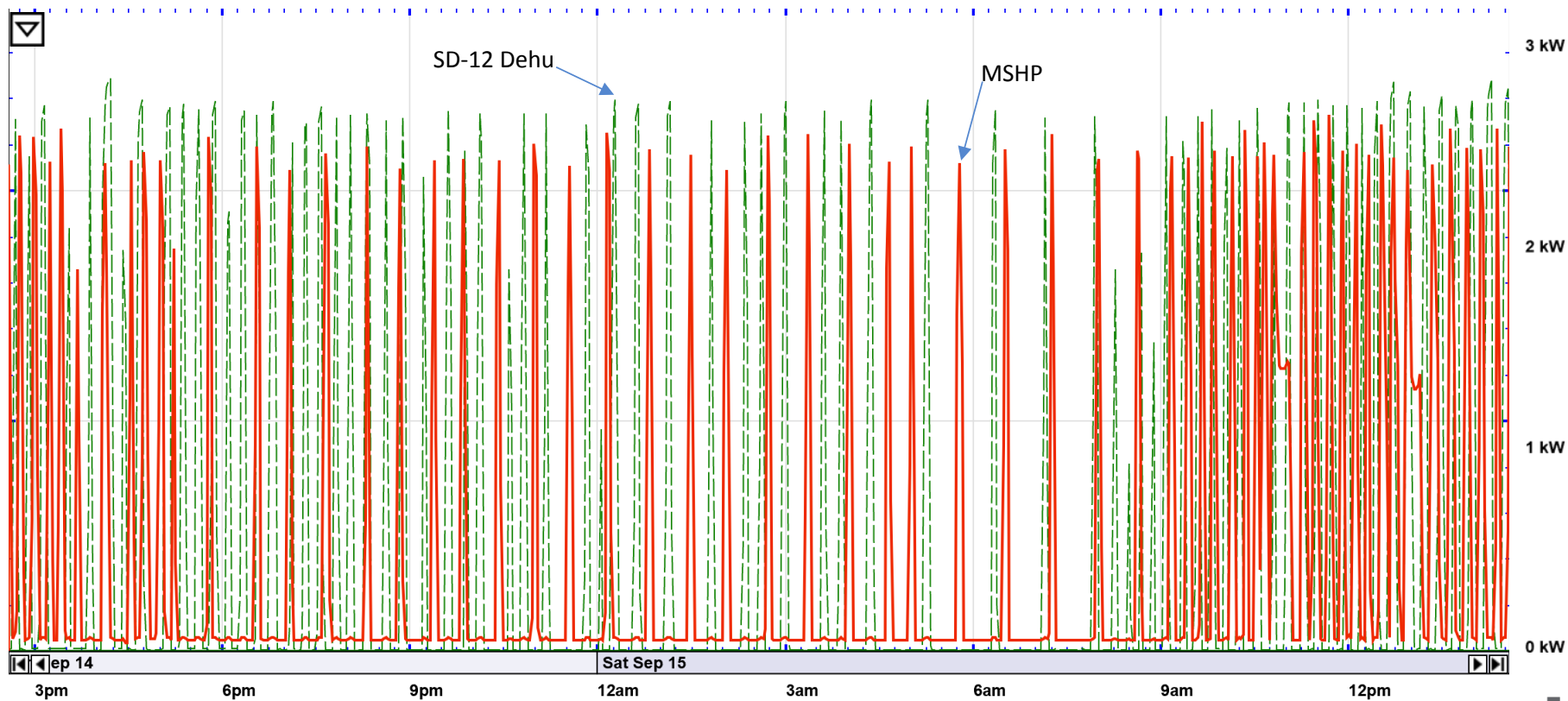
Design for Latent Control

- Complete an interior moisture balance equation
- Determine dehumidification strategy & equipment
 - Systems that can independently control moisture and temperature
- Minimize potential for comfort issues and negative system interactions
- Monitor & make adjustments



SD-12 - No heat added
Latent – 6600 btuh
Sensible – 5100 btuh

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Hurricane Florence

